Claims

What is claimed is:

1. An image data analysis method for inspecting pads of electronic devices, the method comprising:

    acquiring an image corresponding to a pad;

    generating binarized image data from the image;

    generating a list of dark regions from the binarized image;

    selecting at least one dark region from the list of dark regions;

    generating edge data by performing edge detection on a portion of the image corresponding to the at least one dark region; and

    computing a boundary description of the at least one dark region using the binarized image data and the edge data.

2. The image data analysis method of claim 1 wherein the step of acquiring an image further comprises:

    registering the pad by searching the image for a known model of the pad; and

    masking a region not corresponding to the pad, whereby the image is limited to a region corresponding to the pad.

3. The image data analysis method of claim 1 wherein the step of generating edge data further comprises:

    positioning a geometric mask at a plurality of mask positions tangent to the edge data; and

    pruning the at least one dark region of at least a portion of boundary description not contained by the mask positions.

4. The image data analysis method of claim 3 wherein the geometric mask is circular.

5. The image data analysis method of claim 3 further comprising the application of a fuzzy threshold according to an aspect ratio of the at least one dark region for limiting the pruning step.

6. The image data analysis method of claim 1 further comprising:

generating a first elliptical representation of an extremal end of the at least one dark region;

generating a second elliptical representation of a subset of the edge data corresponding to a region adjacent to both sides of the extremal end of the at least one dark region;

generating a third elliptical representation of the edges used in the first and second elliptical representations; and

pruning the at least one dark region in response to a comparison of the first elliptical representation, the second elliptical representation and the third elliptical representation.

7. The image data analysis method of claim 6 wherein the step of pruning the at least one dark region further comprises:

calculating a fit error of the first elliptical representation and a fit error of the second elliptical representation and a fit error of the third elliptical representation; and

pruning the at least one dark region using the elliptical representation having a minimum fit error.

8. The image data analysis method of claim 1 wherein the step of computing a boundary description further comprises reporting measurements including a bounding box description, area, or center of mass.

9. An image data analysis method for inspecting pads of electronic devices, the method comprising:

acquiring an image corresponding to a region of inspection;

generating binarized image data from the image;

generating a list of dark regions from the binarized image;

selecting at least one dark region in the list of dark regions, the at least one dark region having at least one distal end;

pruning necks from the at least one distal end of the at least one dark region to provide a modified region; and

computing a boundary description of the modified region.

10. The image data analysis method of claim 9 wherein the step of selecting at least one dark region further comprises the application of an elongation threshold filter, whereby only dark regions in the list of dark regions having a length to width ratio exceeding the elongation threshold are selected.

11. An image data analysis method for inspecting pads of electronic devices, the method comprising:

acquiring an image corresponding to a region of inspection;

generating binarized image data from the image;

generating a list of dark regions from the binarized image;

generating edge data by performing edge detection on a portion of the image corresponding to a plurality of dark regions;

applying heuristic refinement of a plurality of the dark regions using the binarized image data and the edge data to provide a set of modified regions;

merging at least two modified regions to provide a merged region; and

computing a boundary description of the merged region.

12. The image data analysis method of claim 11 wherein the edge data is subsequently chained to provide edge chain data, and the heuristic refinement step considers edge chain data that form a closed region to provide a considered closed chain region.

13. The image data analysis method of claim 11 wherein the merging step further comprises applying heuristic refinement of the merged region.

14. The image data analysis method of claim 12 wherein the merging step further comprises applying heuristic refinement of the merged region, wherein the heuristic refinement of the merged region rescinds the considered closed chain regions within the merged region.

15. An image data analysis system comprising:

    means for acquiring an image corresponding to a region of inspection;

    means for generating binarized image data from the image;

    means for generating a list of dark regions from the binarized image data;

    means for selecting at least one dark region from the list of dark regions;

    means for generating edge data by performing edge detection on a portion of the image corresponding to the at least one dark region; and

    means for computing a boundary description of the at least one dark region using the binarized image data and the edge data.

16. The system of claim 15 wherein the means for acquiring an image corresponding to a region of inspection further comprises a camera, and a machine vision processor coupled to the camera.

17. The system of claim 16 wherein the means for computing a boundary description of the at least one dark region further comprises a processor for heuristic refinement of the binarized image data and the edge data.

18. The system of claim 17 wherein the processor further comprises a means for positioning a geometric mask at a plurality of mask positions, the mask positions tangent to the edge data in the image, and a means for pruning the at least one dark region of at least a portion of the boundary description not contained by the mask positions.

19. The system of claim 18 further comprising a means for applying a fuzzy threshold according to an aspect ratio of the at least one dark region for limiting the pruning means.

20. The system of claim 15 further comprising:

    means for generating a first elliptical representation of an extremal end of the at least one dark region;

means for generating a second elliptical representation of a subset of the edge data corresponding to a region adjacent to both sides of the extremal end of the at least one dark region;

means for generating a third elliptical representation of the edges used in the first and second elliptical representations; and

means for pruning the at least one dark region in response to a comparison of the first elliptical representation, the second elliptical representation and the third elliptical representation.

21. The system of claim 20 further comprising:

means for calculating a fit error of the first elliptical representation and a fit error of the second elliptical representation and a fit error of the third elliptical representation, and;

means for pruning the at least one dark region using the elliptical representation having a minimum fit error.

22. The image data analysis system of claim 15 wherein the step of computing a boundary description further comprises reporting measurements including a bounding box description, area, or center of mass.

23. An image data analysis apparatus for inspecting a scene, the apparatus comprising:

means for acquiring an image corresponding to a scene;

means for generating binarized image data from the image;

means for generating a list of dark regions from the binarized image;

means for selecting at least one dark region in the list of dark regions, the at least one dark region having at least one distal end;

means for pruning necks from the at least one distal end of the at least one dark region to provide a modified region; and

means for computing a boundary description of the modified region.

24. The apparatus of claim 23 wherein the means for selecting at least one dark region further comprises an elongation threshold filter.

25. An image data analysis system comprising:

    means for acquiring an image corresponding to a region of inspection;

    means for generating binarized image data from the image;

    means for generating a list of dark regions from the binarized image;

    means for generating edge data by performing edge detection on a portion of the image corresponding to a plurality of dark regions;

    means for applying heuristic refinement of a plurality of the dark regions using the binarized image data and the edge data to provide a set of modified regions;

    means for merging at least two modified regions to provide a merged region; and

    means for computing a boundary description of the merged region.

26. The image data analysis system of claim 25 wherein the merging means further comprises a means for heuristic refinement of the merged region.

27. An image data analysis method for inspecting scenes, the method comprising:

    acquiring an image of a scene;

    generating binarized image data from the image;

    generating a list of dark regions from the binarized image;

    selecting at least one dark region from the list of dark regions;

    generating edge data by performing edge detection on a portion of the image corresponding to the at least one dark region; and

    computing a boundary description of the at least one dark region using the binarized image data and the edge data.

28. The image data analysis method of claim 27 wherein the step of generating edge data further

comprises:

positioning a geometric mask at a plurality of mask positions tangent to the edge data; and

pruning the at least one dark region of at least a portion of boundary description not contained by

the mask positions.

29. The image data analysis method of claim 28 wherein the geometric mask is circular.

30. The image data analysis method of claim 28 further comprising the application of a fuzzy threshold

according to an aspect ratio of the at least one dark region for limiting the pruning step.

31. The image data analysis method of claim 27 further comprising:

generating a first elliptical representation of an extremal end of the at least one dark region;

generating a second elliptical representation of a subset of the edge data corresponding to a region

adjacent to both sides of the extremal end of the at least one dark region;

generating a third elliptical representation using the edged from the first and second elliptical

representations; and

pruning the at least one dark region in response to a comparison of the first elliptical

representation, the second elliptical representation, and the third elliptical representation.

32. The image data analysis method of claim 31 wherein the step of pruning the at least one dark region

further comprises:

calculating a fit error of the first elliptical representation and a fit error of the second elliptical

representation and a fit error of the third elliptical representation; and

pruning the at least one dark region using the elliptical representation having a minimum fit error.

33. The image data analysis method of claim 27 wherein the step of computing a boundary description further comprises reporting measurements including a bounding box description, area, or center of mass.

34. An image data analysis method for scenes, the method comprising:

acquiring an image of a scene;

generating binarized image data from the image;

generating a list of dark regions from the binarized image;

generating edge data by performing edge detection on a portion of the image corresponding to a plurality of dark regions;

applying heuristic refinement of a plurality of the dark regions using the binarized image data and the edge data to provide a set of modified regions;

merging at least two modified regions to provide a merged region; and

computing a boundary description of the merged region.

35. The image data analysis method of claim 34 wherein the edge data is subsequently chained to provide edge chain data, and the heuristic refinement step considers edge chain data that form a closed region to provide a considered closed chain region.

36. The image data analysis method of claim 34 wherein the merging step further comprises applying heuristic refinement of the merged region.

37. The image data analysis method of claim 35 wherein the merging step further comprises applying heuristic refinement of the merged region, wherein the heuristic refinement of the merged region rescinds the considered closed chain regions within the merged region.